A Collaboration Framework To Advance High-Temperature Superconducting Magnets For Accelerator Facilities

Testing of Mineral-insulated ReBCO Coil with Common Coil Dipole for Advancing High Field HTS/LTS Hybrid Magnet Technology

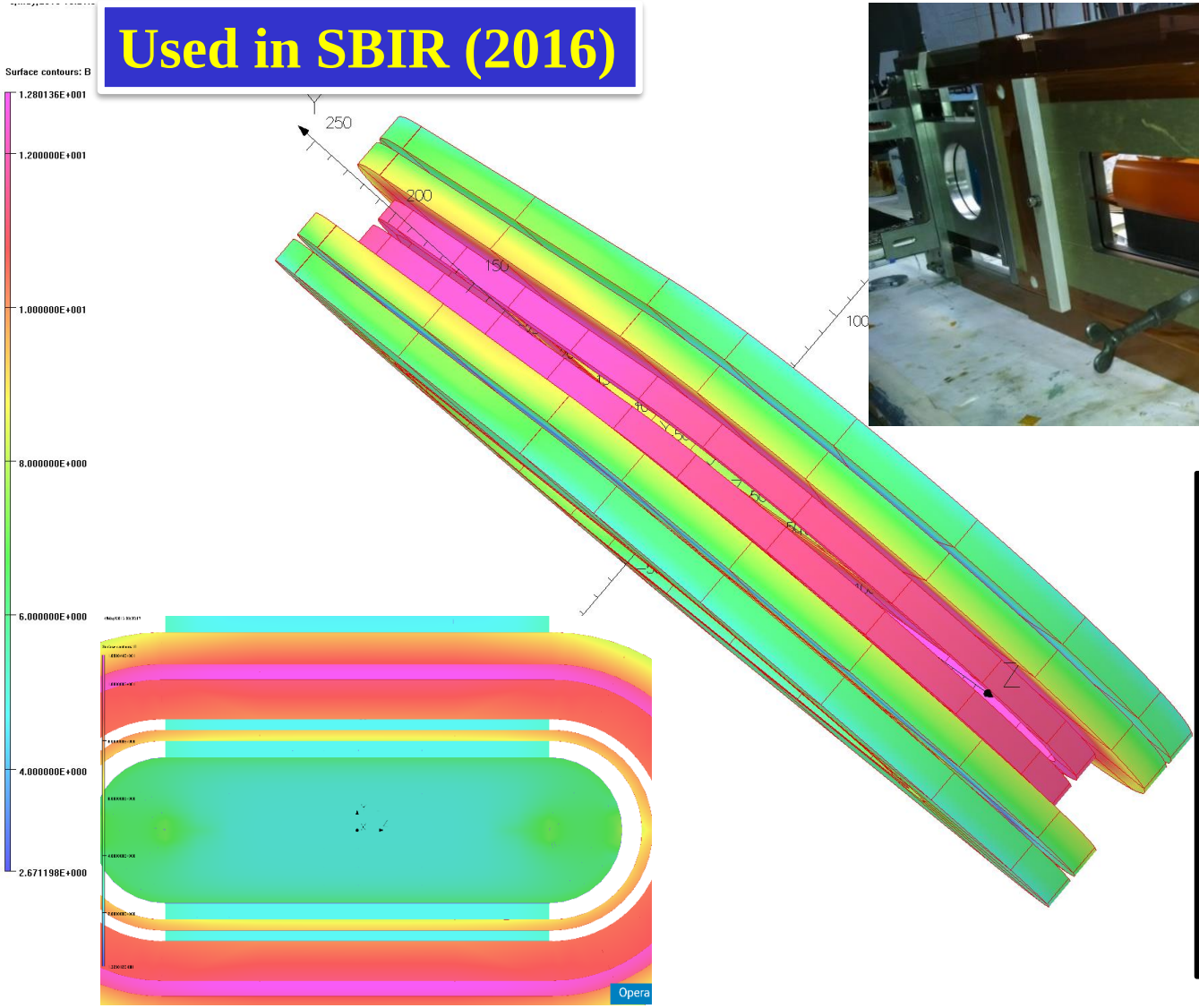
US-Japan HEP Collaboration Meeting

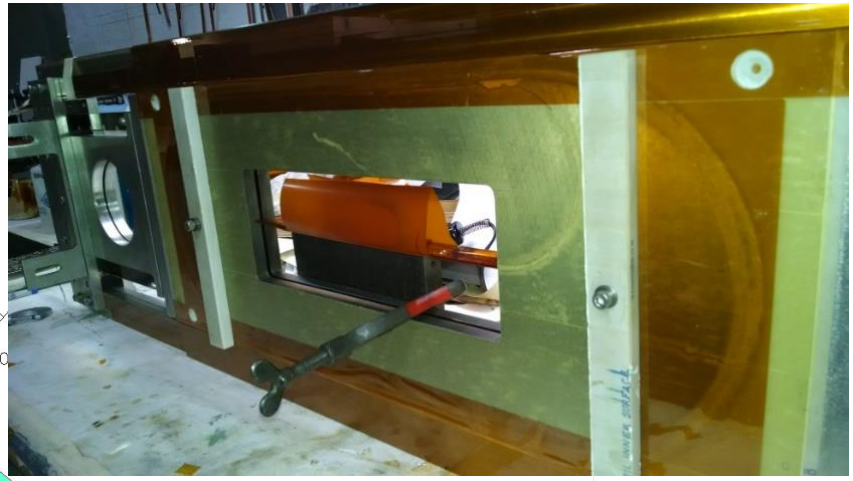
Ramesh Gupta

July 30, 2020

Test Insert Coils in Background Field (configuration #1)

Used in SBIR (2016)

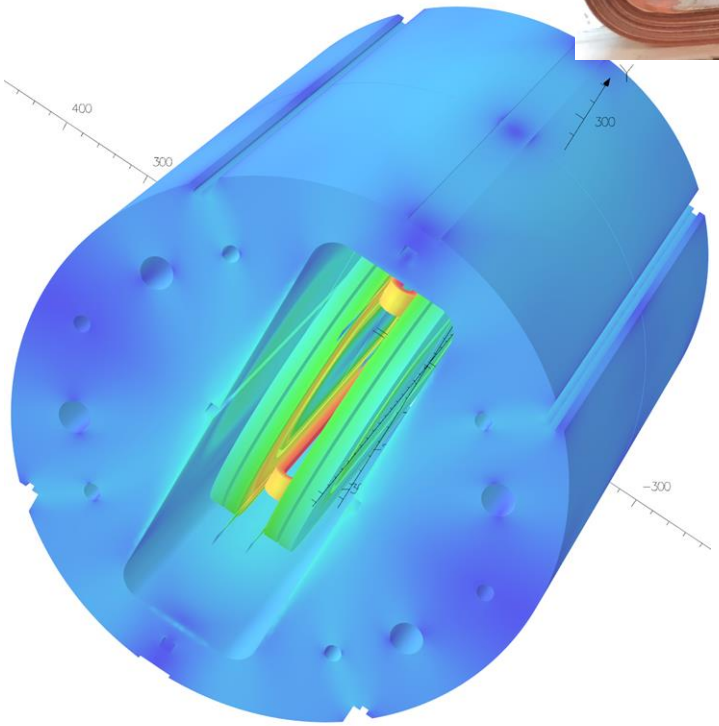


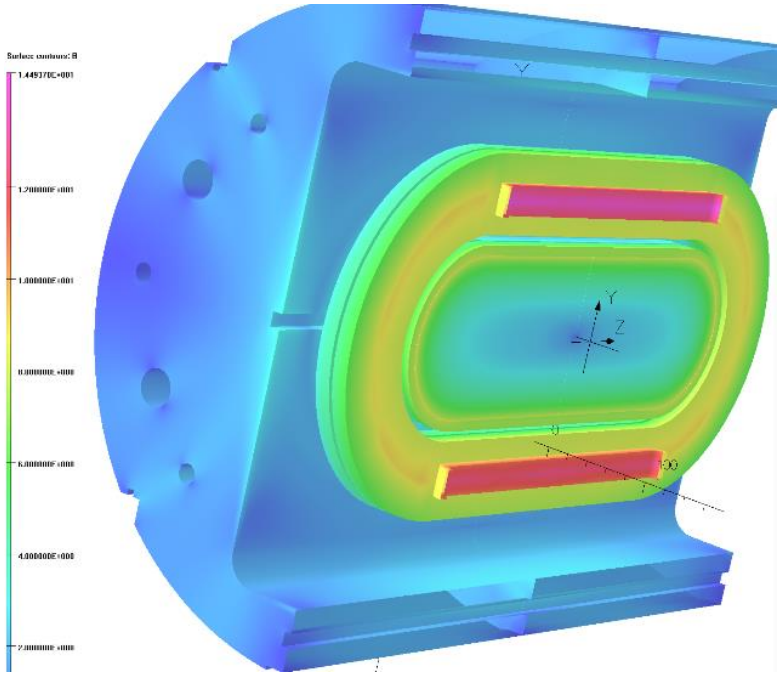


Field predominately perpendicular to the wide face of the tape: unfavorable direction

Test Insert Coils in Background Field (configuration #2)

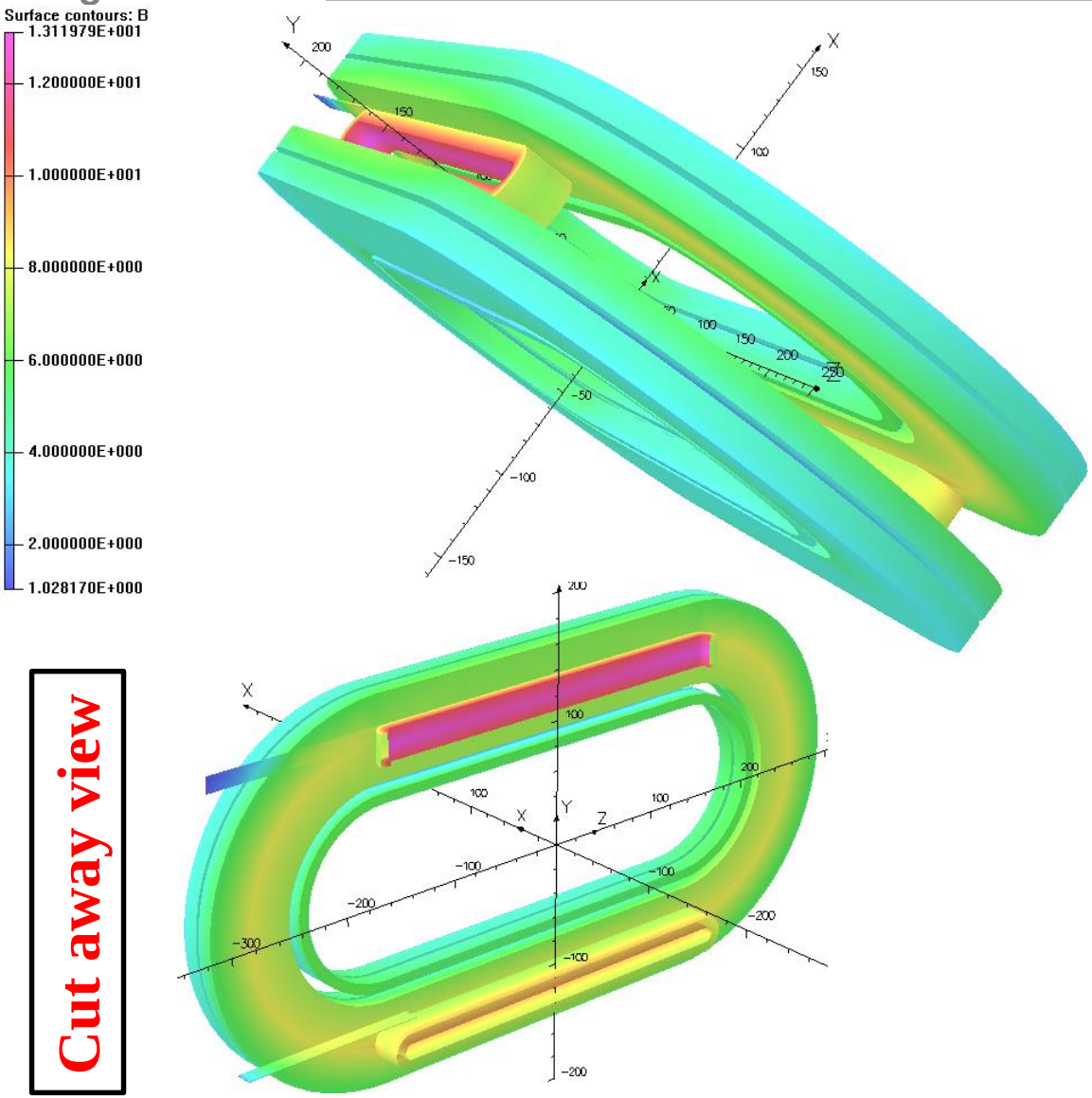
Used in MDP (2020)





Field predominately parallel to the wide face of the tape: favorable direction – both for Je and for magnetization

Insert Coils Test Configuration#4



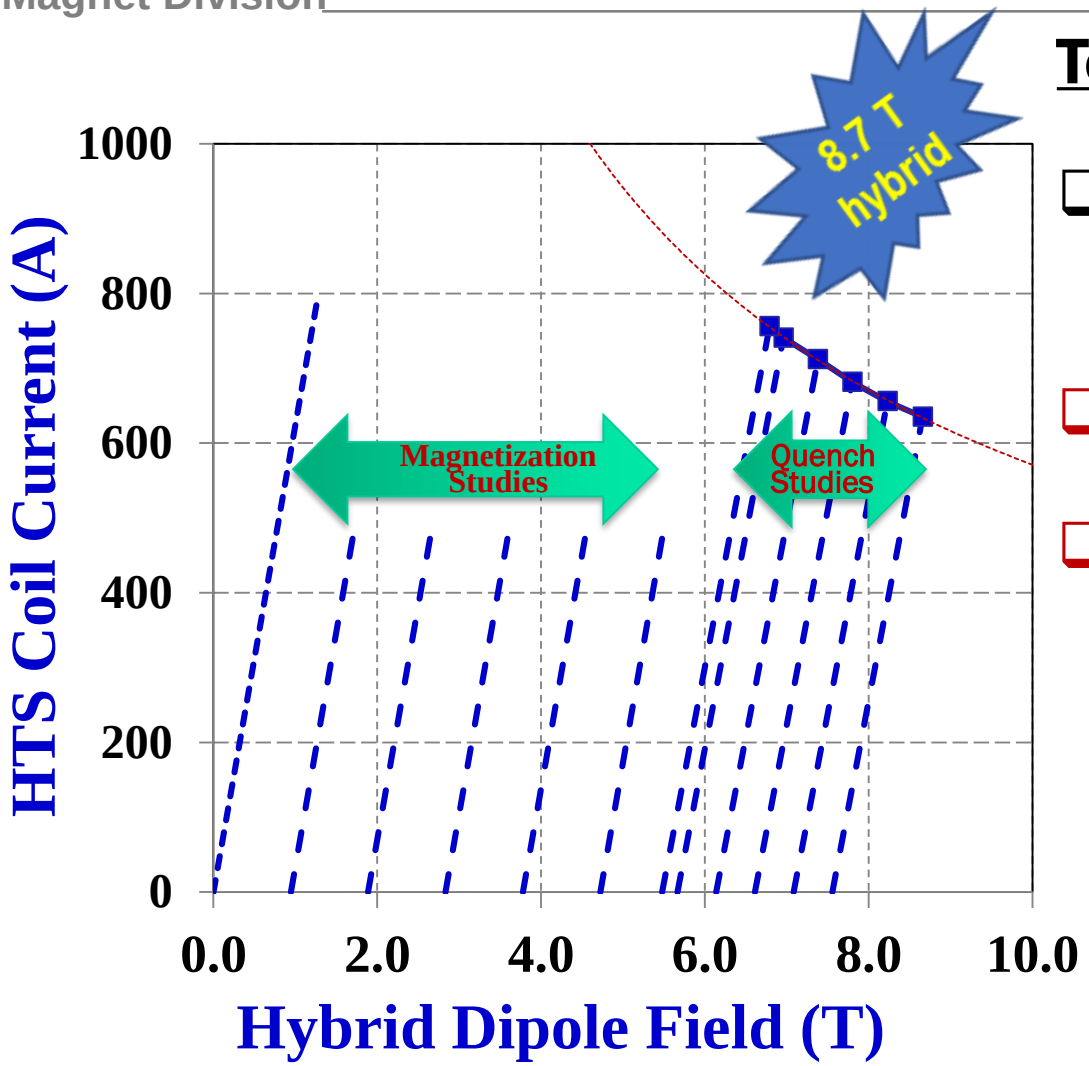
Two HTS insert coils in two bores (apertures) of the common coil dipole

(a) Upper bore: Field primarily parallel (favorable direction)

(b) Lower bore: Field primarily perpendicular (unfavorable direction)

Proposed for US-Japan HEP Collaboration Test

HTS/LTS Hybrid Dipole Test (2016)



Reported at MT25

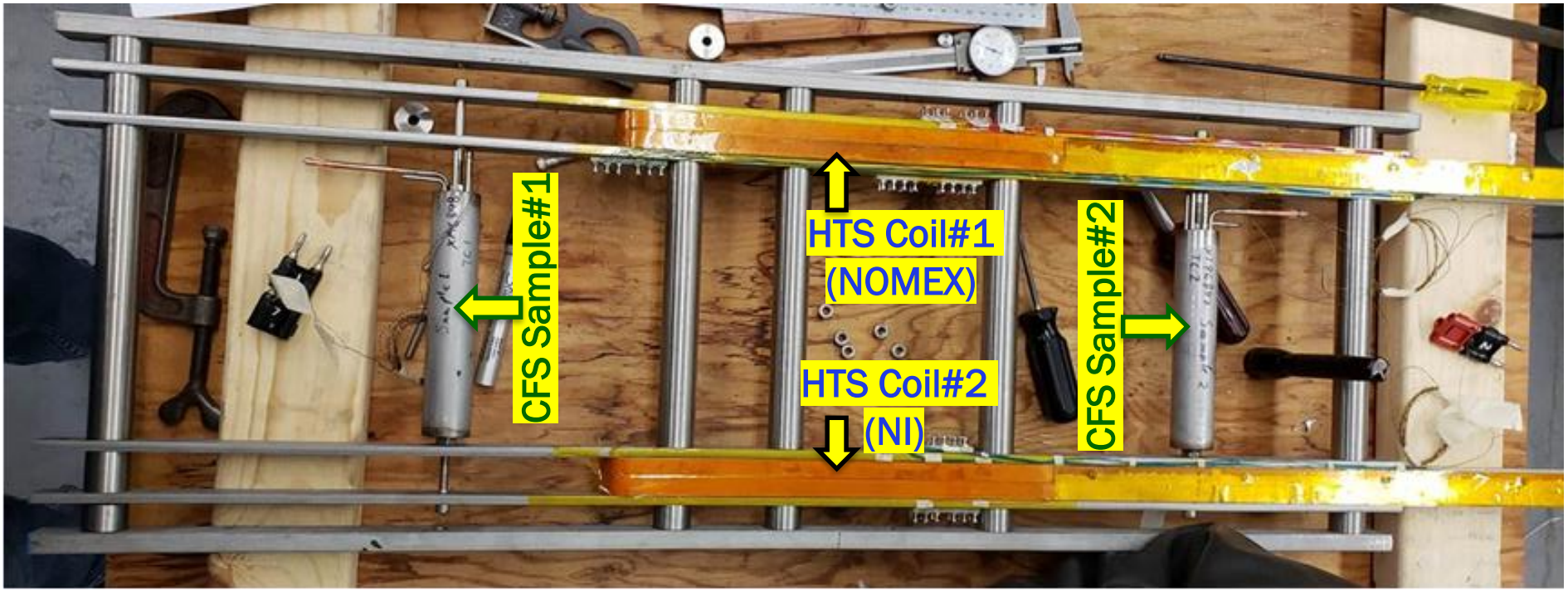
Test performed under SBIR:

- HTS coils were ramped to quench, just like LTS coils
- HTS coils had no training
- No damage, no degradation despite several quenches

Question unanswered: What would happen to HTS coils if LTS coil quenches and dumps a large stored energy due to coupling?

MDP Hybrid Dipole Test (2020)

A multi-test platform (four tests in one go)



KEK should provide HTS coils (pre-tested at 77 K) in a structure that can be inserted in DCC017

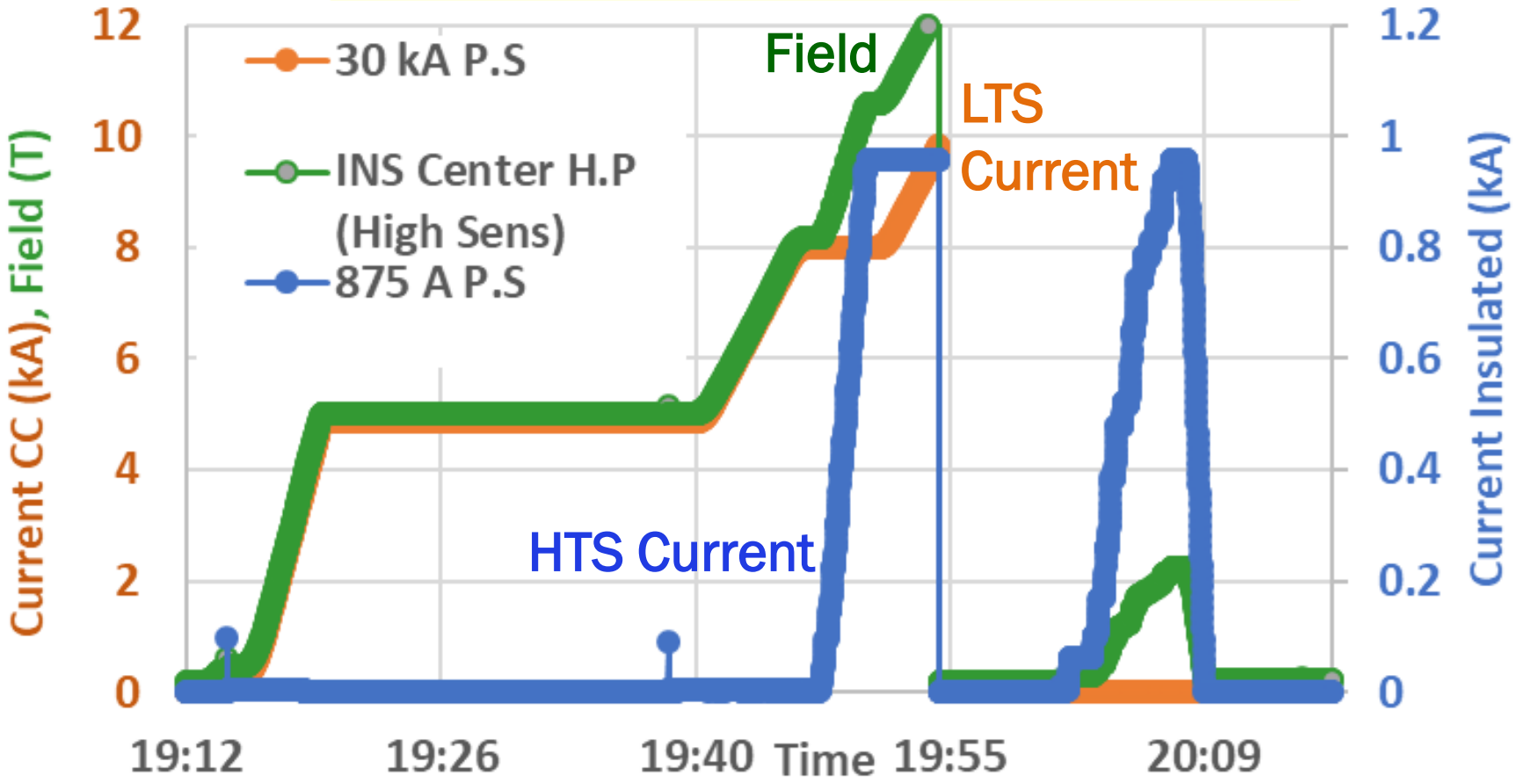
BROOKHAVEN NATIONAL LABORATORY

Superconducting Magnet Division

MDP HTS/LTS Hybrid Dipole (2020)
(HTS coils survived many quenches in LTS)

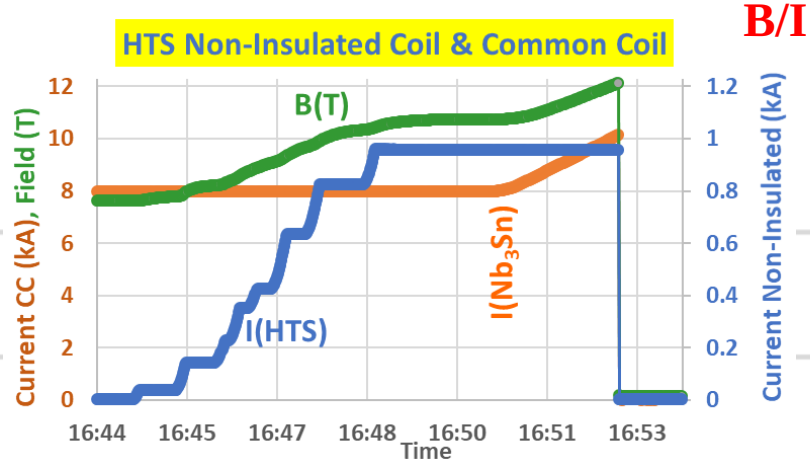
2/13/20

HTS Insulated Coil & Common Coil



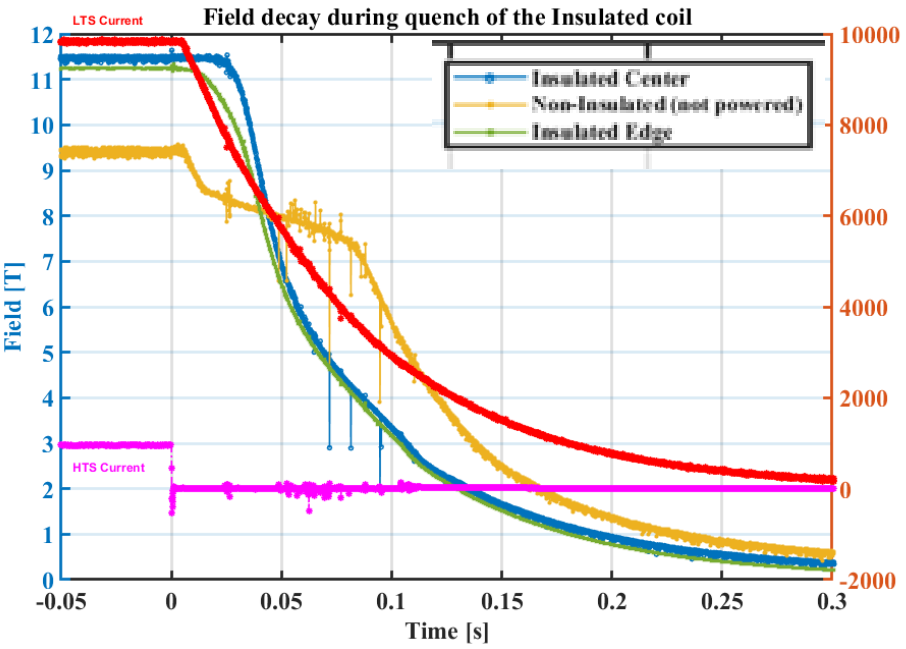
ReBCO/Nb_3Sn Hybrid Dipole with NI Coils

B/I tracking in NI coils not as bad as feared



Comparison of Insulated and NI HTS Coils (unique test from 2-in-1 hybrid dipole)

Insulated Coil



I(LTS)

I(HTS), insulated coil

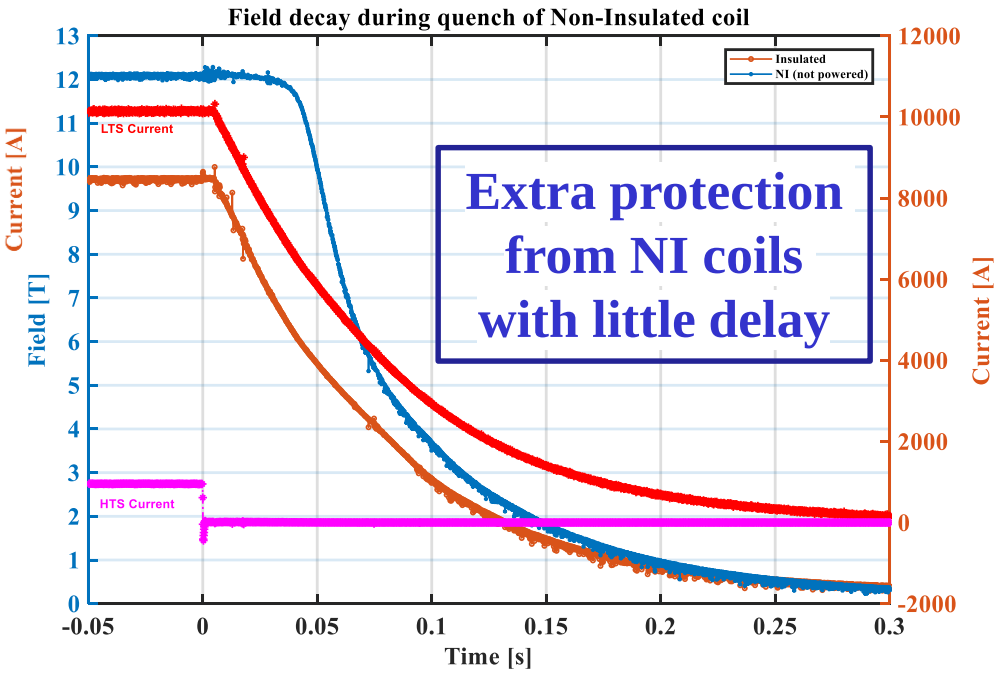
B at the center of insulated coil

B at the edge of insulated coil

B at the center of NI coil (not powered)

Very interesting results from NI coils

Non-insulated Coil



I(LTS)

I(HTS), non-insulated coil

B at the center of non-insulated coil

B at the center of insulated coil (not powered)

Lessons learnt that are relevant to US-Japan HEP Collaboration Test (1)

- **HTS coils remained protected despite many quenches and trips in LTS coils dumping energy in HTS coils.**
- **Quenching HTS coils was limited by the power supply.**
- **MDP coils were made with 12 mm wide tape, whereas KEK coils will be made with 4 mm wide tape.**
- **We should be able to get to the quench current at any reasonably low field in the configuration when the field from Nb_3Sn coils is predominately perpendicular (unfavorable) to the wide face of the tape, however, not necessarily when it is predominately parallel (favorable).**

➢ **New power supply and quench system is part of this year budget**

Lessons learnt that are relevant to US-Japan HEP Collaboration Test (2)

- **The maximum hybrid field was not limited by the HTS coils, but interestingly it was limited by the LTS coils.**
- **There was no structure between HTS coils and LTS coils. HTS coils, pushed by the Lorentz forces, directly leaned against the LTS coils. This created a local high stress/strain region in Nb_3Sn coils of the common coil magnet – discontinuity where the HTS coils ended.**
- **We tried several combinations of the currents in the HTS and LTS coils, but the maximum reachable field was always limited by the LTS coils.**
- **KEK coils should have a support structure which either contains the Lorentz force or at least distributes them.**